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ABSTRACT

Scientific literacy is far more than knowing a list of terms and definitions. Scientific literacy is the ability to do processes related to a specific scientific field and knowing, at minimum, basic problem solving. This paper discusses what students need to know in the different science and mathematics fields and describes the teacher's role in this process. (MVL)

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True Scientific Literacy for All Students

by **Stewart E Brekke, MS in Ed, MA**
Physics teacher (retired)
Chicago Public Schools

What is Scientific Literacy?

Scientific literacy is far more than knowing a list of terms and definitions. Scientific literacy is the ability to do processes related to a specific scientific field and knowing, at minimum, basic problem solving. Chemical literacy involves, for example, how to find the formula for carbon dioxide, or barium nitrate. It involves, at minimum, how to predict the products given two reactants in a chemical reaction and how to balance a simple chemical equation describing what has happened.

Physics literacy involves more than simply stating the formula for speed. Physics literacy is achieved when a person can state the speed of an object given the distance traveled and the time taken by the object to travel that distance. Physics literacy on the high school level involves taking data in an experiment, organizing it in a chart, and even possibly finding an approximate curve to fit the data and predict future outcomes of the phenomena. The minimum level of literacy in high school mathematics is knowing how to solve a basic algebraic equation and possibly how to do a simple deductive geometric proof.

It is untrue that knowing definitions of a list of terms or simply observing physical or biological phenomena, and making uninformed conclusions about these events, are sufficient conditions for scientific literacy in the high school or in higher education. The verbal method of classifying and organizing in today's highly scientific and technological society is simply not enough to be able to function with sufficient success. All the sciences, even the

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About Stewart E Brekke...

Stewart E Brekke at 59 year old has just retired from his position as a physics and chemistry teacher in the Chicago Public Schools. He taught for just over 23 years with the Chicago district and

biological sciences, are based on the mathematical interpretation of nature. And preparation in at least algebra and basic solving of algebraic equations is essential for the solving of problems using formulas. All the sciences strive to reduce their phenomena to simple mathematical relations such as E = mc^2, or PV = nRT. Ability to calculate the energy conversion, given a mass such as in Einstein's mass-energy equation in physics and/or chemistry, or to solve for pressure, volume or time given the value of two of the variables, is well within an average high school student's capability, especially with the use of basic scientific calculators or even simple arithmetic calculators. I have found over many years of teaching physics and chemistry that even slow learners and many learning disabled students often do basic algebra and simple to complex physics and chemistry problem solving if properly shown how and given sufficient practice.

In many high school districts across the country, the upper twenty percent of students take physics. A greater number, but not all students, take chemistry. If the less academically inclined or slower students do take physics or chemistry, the course they get is often watered down and is mostly of a qualitative nature. These students get a false sense of science as a descriptive enterprise, often learning to copy answers out of a text and comprising interesting but non-mathematical experiments and spectacular demonstrations. When they get to college or the university level physics and chemistry course, they are unprepared for the reality of a mathematical course and often do not do well. They have been given a false impression that they have physics or chemistry literacy, when they do not because they did not learn the essentials of science (primarily the mathematical component of using formulas to describe scientific phenomena...even sometimes biological as well as physical).

The Teacher's Role

After many years of teaching physics and chemistry to inner city students, many of whom were at-risk nor very academically inclined, I can say with authority that to provide these students with the standard mathematical course in physics and chemistry requires a substantial extra effort by the teacher. However, the basic mathematical course providing true scientific literacy to all students can be done with little expense.

Most standard texts do not have sufficient drills and practices of the required problems to be solved and the

just over 1 year with approximately 20 surrounding suburban districts, full time and substituting. Mr. Brekke's publishing record includes articles on teaching science in The Physics Teacher and the ISTA Spectrum as well as letters to the editor in Physics Today and The Science Teacher. He has presented two papers to the Illinois State Academy of Science, Physics section.

Stewart holds three degrees: An MS in Ed from Purdue, an MA in Humanities from Wayne State University, and a BA from the University of Illinois. His interests are Physics and Chemistry teaching as well as the Minoan-Mycenean religion, having had two articles on Minoan religion published in scholarly journals. His interest in Physics and Chemistry teaching centers around teaching to minority students the standard mathematical Physics and Chemistry course taught most often to the best students, and not often presented to students perceived as "at risk." He asserts that, "Most students, average and above, can do the standard mathematical course, if they have appropriate support, and are taught with drills and practices not usually given in high school Physics and Chemistry texts."

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teacher must provide on the board or on ditto paper extra problem solving practice, perhaps six to eight problems per formula in which the student solves for all variables. The substantial effort is by the teacher who must go around the room visiting as many students as possible and helping with the problem solving techniques such as isolating values for variables, organizing problems, and solving for different variables.

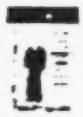
Also, many at-risk students and the non-academically inclined students are weak in fractions and decimals. I buy 10-15 cheap arithmetic calculators and let the students use them throughout the year. The calculators are essential for successful problem solving by these at-risk students. Sometimes, I buy basic scientific calculators such as the Texas Instruments TI-30 which allows the students to quickly calculate in scientific notation. I have found that problem solving literacy in a basic but mathematical physics or chemistry course will take place after about 3 or 4 months of the teacher providing this intensive help.

Labs in physics and chemistry can easily be quantitative if the teacher makes the labs straight forward and adequate help is given. Instead of letting the students sit trying to figure out how to do the labs, I often help them set up the labs and show them how to take the data. We want learning to take place, not confusion, therefore helping the students learn about the factors of the experiment, is very proper. Literacy about physics or chemical phenomena is accomplished when the student completes the laboratory work, not when he/she spends the entire lab period trying to figure out how to set up the apparatus or how to interpret the data.

I often require a graph of the data. Even at-risk and non-academically inclined students can model data in some basic form by using the approximate best fit method of finding a curve to fit the plotted data points using pictures of standard curves such as parabolas, hyperbolas, and lines and trying to fit the equations for them (such as y =kx, y= kx*2, y = k/x). At first, substantial effort by the teacher is needed to help with the Basic curve fitting and formula for the curve, but the effort by the teacher often pays off in a literate student being produced by the end of the course in June.

In Summary

It is worth the substantial effort a teacher must often put forth in order to provide at-risk students the additional



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practice and experiences necessary to develop scientific literacy. True scientific literacy given in the standard mathematical course will enhance rationality and other thinking skills. Reasoning and organizing a physics or chemistry problem and solving it as well as using various types of reasoning processes in the physical sciences, especially mathematical, forms a base upon which logical thinking can be transferred to other fields such as in the humanities and social sciences. Developing an understanding of the mathematical part of physics and chemistry, as well as biology, in the high school, provides the student with the ability to function in an increasingly technological world, building the foundation upon which thinking logically and clearly be built.

Any discussion of scientific literacy must include not only facts of science areas, but also a literacy of the mathematical foundations and processes of physics and chemistry, which also provide the basis of biology and must be addressed when discussing true scientific literacy.

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